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## GENERAL REVIEWS AND SUMMARIES

### RECENT LITERATURE ON TROPISMS AND INSTINCTIVE ACTIVITIES

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Allee (1, 2) asserts that the rheotactic reaction alone is not sufficient to account for the position isopods assume in streams, and that the thigmotaxis is also of importance. The molting period and breeding season are important in the ecology of stream isopods since they decrease the clinging ability. Other experiments show that the survival time in potassium cyanide is, for *Asellus communis*, inversely proportional to the rate of metabolism. Since isopods which are strongly positive to current have a much shorter survival time than those which are indifferent, it appears that high positiveness to current is an expression of a relatively high rate of metabolism.

Allen's (3) investigations show that in fresh water mussels the surfaces of the gills, the end of the upper part of the mantle, and the labial palps serve to carry food to the mouth. The food supply is not regulated but the amount of digestive juices secreted, and hence of digestion accomplished, depends upon the need for food. Digestion seems to be mostly accomplished in the stomach as few living organisms were found to have entered the intestine. A discussion of the possible use of the crystalline style is given.

Armbruster (4) in a very interesting paper on humble-bees describes the architecture and building materials of the nests, relation of sexes, color varieties, and orientation. He believes that bees usually find the way back to the hive by "optical signals"

but that they are also, after they have traveled a route many times, able to find it "blind" as an expert player is able to pick out the keys on a piano.

Babcock (5, 6) has made observations on the hibernating habits of the jumping mouse. Torpidity is periodic at the beginning of the season, lasting for only short intervals. The length of the period of hibernation is probably not entirely determined by temperature. In another paper this author states that the shrew, *Blarina brevicauda*, consumes very large quantities of food, sometimes several times its own weight in the course of a day. Since its food consists mainly of insects, other small animals, especially mice, and a little vegetation, it is of great economic importance.

Banta (7) writes an interesting description of the mating behavior of the wood frog, *Rana sylvatica*. Usually a female is clasped by but one male. Occasionally she may be pursued by a number, and a battle ensues in which she is often the one to suffer. It is possible that in sex recognition color and the peculiar behavior of the female play a part, but finally a chemical sense seems to be involved, although the one experiment designed to test this was unsuccessful.

Beck (8) discusses the importance of electrical phenomena in the central nervous system of the frog and presents experimental work.

Bittner, Johnson, and Torrey (9) have reëxamined the reaction methods of the earthworm to light. They maintain that there are neither random movements nor "trials," but that orientation is direct.

Using very sensitive apparatus Bose (10) has studied the rate of transmission of excitation in the sensitive plant. The latent period grows shorter as the stimulus is increased until the minimum is reached, the shortest being 0.06 second. Variation in temperature influences the rate of transmission (12.5 mm. per second at 31 degrees C.; 6.6 mm. at 23 degrees C.). From various experiments with electricity and temperature Dr. Bose concludes: "These results prove conclusively that the transmission of excitation in the plant is a process fundamentally similar to that which takes place in the animal."

Brunacci (11) finds that the frog, *Rana esculenta*, is greatly affected internally by changes in the concentration of its liquid environment. 10 per cent. solution of NaCl is maximal. Beyond this great metabolic changes occur in the water content of the tissues.

Buttel-Reepen (12) gives a lengthy review of the continental work on the relations of bees to flowers and discusses some observations of his own. He believes that odor is less important than color in attracting bees to blossoms. He also asserts that, though humble-bees often break through the corolla to rob flowers of their nectar, honey-bees seldom do so.

Cameron and Brownlee (13) have investigated the ability of frogs and their tissues to survive low temperatures. They give a complete review of recent literature and present experimental work. "Frogs freeze at a temperature of − 0.44 degree C. to − 0.02 degree C. in a manner very similar to that of solutions isotonic with their body-fluid." Heart tissue will survive a temperature of − 2.9 degrees C. Frogs probably die at low temperatures on account of a specific effect on the brain or spinal cord.

Cowles (14) found that the starfish, *Echinaster spinosus*, when put into a black box illuminated from above would nearly always move toward a white card placed on one side of the wall. He believed this reaction was caused by the reflection from the card which caused the side of the starfish nearest to it to receive more light.

Crozier (15) finds that *Holothuria captiva* is photokinetic, its whole surface being sensitive. Although this sea-cucumber does not respond to an increase in intensity of light, it withdraws when shaded. It moves only with the anterior end in advance and is negatively phototropic. The green fluorescent integumentary pigment probably acts as a sensitizer.

Experiments were performed by Miss Dale (16) to determine the limits of hydrogen ion concentration fatal to Paramœcium. The action of the hydrogen and hydroxyl ions and of the polyvalent kations and anions may perhaps be ascribed to the power possessed by these of conferring electric charges on colloidal materials with which they come in contact.

Dice (17), in an excellent paper on the movements of Daphnia discusses the effects of temperature, light, gravity, mechanical stimulation, chemical content of water, age, and other factors. He concludes that, "the diurnal movements of *Daphnia pulex* are caused chiefly by changes in light intensity. The limits of the diurnal movements are determined by the factors effective in producing the seasonal movements. . . . Much of the behavior of Daphnia is determined by orientation to various stimuli, but some regulatory behavior is obtained by means of random movements.

. . . Change in geotaxis by changes in light intensity and in temperature has been observed in other plankton organisms, and is probably of widespread importance in determining the vertical movements of plankton."

Dupont (18) states that the mechanical irritation of the semicircular canals in cartilagenous fishes causes reflex movements of the eyeball.

Hahn (19) describes the hibernating habits of the bear, woodchuck, bat, and ground squirrel. He had a pet ground squirrel which, although kept in the laboratory, slept for varying lengths of time whenever the room temperature was allowed to fall near the freezing point.

Hamilton (20) has studied the sexual behavior of monkeys confined in large cages or allowed to run free out doors. "At least two, and possibly three different kinds of hunger, or needs of individual satisfaction, normally impel the macaque toward the manifestation of sexual behavior, viz., hunger for sexual satisfaction, hunger for escape from danger and, possibly, hunger for access to an enemy." Homosexual relations are of common occurrence, even when members of the opposite sex are present.

Kanda (21) discusses mechanical, pressure, resistance and statocyst theories of geotropism with reference to Paramœcium and Spirostomum, concluding that the statocyst theory is probably correct, though not yet proved. He also shows (22) that the negative geotropism of the larva of *Arenicola cristata* is reversible by calcium and magnesium salts, but not by sodium and potassium salts. This is probably due to the $Mg^{++}$ and $Ca^{++}$ ions. The positive reaction to light is negatived by NaCl, KCl, MgCl, and by seawater after exposure to $CaCl_2$ solution. Acids, alkalis and narcotics, so far as tried, did not reverse the geotropism of this larva.

Lashley (23) notes two instances of the persistence of the sucking instinct of cats into adult life.

Levick's (24) account of the nesting habits of Adelie penguins gives many points of interest. The males fight for mates but the victor does not always get the female sought. "As a rule it is the strongest and cleverest fighter of the group; but, curiously, this is not always so, as sometimes the bird who has undoubtedly proved himself the victor suddenly walks off, and by general consent his vanquished opponent is left in possession of the field." The recognized suitor must next be accepted by the female, and is often kept courting for some time. Once a pair is mated, how-

ever, no bachelor male can break up the match. The cock fetches stones for the nest, which the hen builds. "The adult birds are very fond of playing games." In order to have time for such recreation and to feed, they take turns with the incubation and the care of the young. A number of pairs may coöperate in the latter duty.

According to Lillie (**25**) the irritability of living organisms is due to changes in the permeability of the plasma membrane. These changes depend upon slight variations in external conditions, especially electrical phenomena. Variations in the speed of response and sensitivity depend primarily on the specific peculiarities of the plasma membranes of different tissues.

McIndoo (**26, 27**) has made a careful study of the olfactory sense in insects. He makes an extended review of the literature on the subject and concludes "that the organs called the olfactory pores by the author are the true olfactory apparatus in Hymenoptera and possibly in all insects and that the antennæ play no part in receiving odor stimuli . . . it will be realized that the antennæ can no longer be regarded even as a possible seat of the sense of smell in insects."

Polimanti and Mares (**28**) have been disputing about the condition of animals during winter sleep. The former accuses the latter of saying that during hibernation mammals are in a hypnotic state, the usual heat-regulating mechanism not functioning, and they show atavism in that they "return" temporarily to a condition like that in cold-blooded animals. This Mares does not deny but takes exception to Polimanti's assertion that he stated that bile- and gall-secretion were at a standstill during hibernation.

Mast (**29**) in discussing Euglena's method of orientation to light maintains that its responses are brought about by changes in light intensity, contrary to the assertions of Bancroft and Torrey. He also gives a very good discussion of the "trial and error" and "tropism" theories and advocates the abandonment of the latter term because it has been given so many meanings by different authors.

Patten (**30**) has attempted to standardize the reactions of blow fly larvæ to light by subjecting them to the simultaneous action of opposed horizontal beams of light of known intensity. When the two lights were of equal intensity the larvæ followed an almost straight course perpendicular to the line connecting the two lights. When the lightes were unequal they showed a deflection toward

the weaker light, the deflection being proportional to the intensity differences. An arrangement of bilaterally sensitive areas is suggested. The phototactic response is said to depend to a large extent on the stimulating effect of constant light and to follow the Bunsen-Roscoe Law.

Pearl (31) reports observations on the brooding instinct of Barred Plymouth Rock chickens. This instinct normally constitutes one element in the cyclical reproductive activities of hens. Though it usually recurs with greater or less regularity following periods of laying, it may appear in pullets which have laid only one egg and that some little time before. Broodiness appears rather suddenly and usually disappears slowly. Its manifestation is apparently closely connected with the functional activity of the ovary.

Phipps's (32) experiments with three species of amphipods seem to indicate that they respond negatively to changes in light intensity but are more strongly influenced by the direction of rays. When treated with depressing agents such as KCN, chloretone, $CO_2$, and when in a starved condition, many reverse their reaction probably on account of changes in their metabolic processes.

Powers (33) concludes that crayfishes are able to discriminate increases in $CO_2$, and acetic or hydrochloric acids in a gradient, different species reacting to these substances in varying degrees. In general the reaction to hydrochloric acid is the most decided, that to acetic acid next, and that to $CO_2$ the least marked.

According to Roule (34) one of the biological conditions of the migration of salmon up streams is the seeking on the part of the fish of water which is richer in oxygen.

In his little book on the flea Russel (35) describes the sense organs, feeding and mating habits in considerable detail.

Shelford (36) compares the responses of motile and sessile organisms. In the former the most striking responses are changes in position, in sessile animals changes in structure and form are more prominent. In feeding motile animals are more restricted than at other times, while in sessile animals this is not the case, and the dispersal of spores, seeds, and other reproductive bodies serves to spread the species. On this account motile organisms are a better index as to whether conditions are favorable, but sessile organisms are more important as causes of succession, since they effect the surrounding medium more with waste products, skeletons, etc.

The animals of pond and rapids communities differ in their general reactions, according to Shelford (37), but within each community there is an agreement. Pond animals react best to a current of low intensity while those of the rapids prefer a stronger current. Animals of the same community but found at different levels exhibit specific peculiarities, as in their reaction to mud, sand and stone bottoms. Animals living beneath stones show a preference for weak light, those on stones, medium light, and those among stones, strong light.

Shelford (38) has studied the behavior of several terrestrial amphibians and arthropods to air of high evaporating power. Certain of these animals quickly acquired the ability to go to the parts of the experimental cage where the evaporation was least. Some showed increased sensibility with successive trials, and the writer believes this is probably "due to some disturbance in neutrality brought about by concentration" of body fluids. He also states, "there is no reason to assume that associative memory is essentially different or stands apart from the type of modification here described." "It is, therefore, a fairly safe assumption that the capacity to avoid disadvantageous, and the capacity for advantageous, modification are innate also."

Shelford and Allee (39) report the results of experiments to test the behavior of fish in water containing various substances. "Most of the fishes studied reacted negatively to various concentrations of carbon dioxide; to little oxygen; to boiled water with the removed oxygen restored; and to boiled water with acetic acid or carbon dioxide added. The behavior of the fishes when giving a negative reaction usually possessed prominent features. They tried the modified water a number of times and then began to turn back in lower and lower concentrations of the gradient or to spend shorter and shorter time in the modified water with each visit. The response was rhythmical rather than cumulative," but fishes soon learned to avoid the end of the tank where conditions were unfavorable, and when they did enter the modified water remained for shorter periods of time. "The fishes undoubtedly sense the solutes upon entering them." The writers believe that increased sensibility is due to increased tissue acidity. Advantageous reactions are apparently confined to stimuli encountered in everyday life and there is therefore correlation between the conditions of existence and types of irritability. The increased sensibility after repeated stimulation is not believed to be due to associative memory.

Simroth (40) describes his observations on marine gastropods. Colors depend upon pigment, uric acid, and calcium deposits. They frequently serve for warning or protection. Gastropods have many methods of locomotion—through changes of blood, pulsation, swelling, waving lateral parapodia, or gills, etc. Some throw off the gills and dermal processes when molested.

The habits of herring gulls are described and illustrated by Strong (41). These birds nest in large flocks in uninhabited places, particularly islands. They are omnivorous feeders, and hence good scavengers. The breeding season is from the first of May to August. The parents take turns guarding the nest and are ready to fight anything that comes near. Young birds are fed with partially digested food disgorged by the parents. The gulls make a variety of sounds including the alarm cry, the challenge, and the "mewing" for the young. They are easily frightened by sounds, and are sensitive to changes in temperature. They react positively to currents of air. Gulls probably rest during the night except in the breeding season or when food is especially abundant. Their behavior shows some modifiability.

Szymanski (42) has studied the average time of rest and activity of several animals for twenty-four-hour periods. Cockroaches rested during the day and were active from seven to ten hours at night. Goldfish were active mostly during the day. A salamander remained perfectly inactive from November to January. A canary had about the same periods of quiet and activity as man. A white mouse showed sixteen active and rest periods during a day; a gray mouse, nineteen of each.

Vestal (43) in his excellent paper on terrestrial associations points out that ecologically "the characters of plants may be classed as structural, physiological, biographical and numerical. Animals have in addition, behavior or psychological characters."

Wheeler (44) calls attention to a number of points in the behavior of cockroaches, bees, ants, etc., which make them good vehicles for carrying human diseases.

Miss White (45) has studied the reactions of brook trout from the time of hatching until the yolk sac is absorbed. Soon after leaving the eggs the young fish are positively rheotropic and negatively phototropic; light being a more potent stimulus than current. An excess of carbon dioxide in the water causes a rapid swimming without reference to light. Shadows cause no response until the fifth week after hatching and feeding commences at about two months. Sight is the most important sense in learning to feed.

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# RECENT LITERATURE ON SENSORY DISCRIMINATION IN ANIMALS

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To judge from the relative numbers of studies of sensory phenomena in animals, the chief interest at present is in the field of light reactions with auditory, olfactory, and tactual sensibility next in order. But one study of the temperature sense and none dealing directly with organic sensation have appeared during the past year.

*Touch.*—In an extensive study of the function of the vibrissæ in the white rat Vincent (30) finds that the ordinary maze offers little occasion for the use of these organs. In a maze without sides the vibrissæ give the animal orientation with respect to the edges and corners of the maze. At turns they serve as the source of stimuli releasing the kinæsthetic-motor habits of direction. For tactual discrimination a three-alley discrimination box was used, so arranged that any one of the alleys could be fitted with corrugated walls while the other two remained smooth. Normal rats learned quickly to choose the rough surfaces, those lacking vibrissæ learned with greater difficulty, and rats lacking cutaneous sensitivity in the nose, as the result of section of the infra-orbital nerve, failed to learn the problem.

Ackert (1) describes a number of sensory end-organs in the integument of the bat.

Morgulis (22) gives a brief statement of the objective psychology of Pawlow. A number of recent papers from Pawlow's laboratory are reviewed. Only one of these deals directly with sensory acuity. Vassiljev established conditioned salivary reflexes to heat and cold in the dog. It was easy to get responses to these stimuli but they were differentiated only with difficulty. This suggests a close interrelation of the conduction paths (centers) for cold and heat.

*Auditory and Allied Functions.*—Owing to the difficulty of removing the otocysts of the Gastropods, the result of the close anatomical relations of these organs to the pedal ganglion, Baunacke (2) attacked the problem of their function by a process of elimination of other sense organs in reactions to gravity. The snails studied, genera Helix, Arion, and Limax, give two types of reaction to

gravity; they right themselves when turned on the dorsal side and, when immersed in water, migrate from the bottom to the surface film by crawling up the sides of the vessel. Stimuli of light, touch, pressure and the chemical sense were controlled. Operative methods showed that the presence of the ganglionic ring and the otocysts is necessary for orientation to gravity. Baunacke holds that these experiments limit the stimulus for reaction to gravity to the otocysts. Like evidence is advanced to show that the otocysts function in the righting reaction. The method seems to fail to distinguish between otocyst function and other organic sensations of weight.

Rothfeld (25), by severing the neck muscles of the rabbit in order to control the relative position of head and body, has shown that after stimulation of the vestibular apparatus by rotation the type of reaction, as exhibited by increased tonus of the muscles of the back and limbs, is dependent upon the position of the head. The movements of the animals, after rotation with the head in the normal position, change with changes in the position of the head and correspond closely with those described for man with the head in like relative positions to the body.

Turner and Schwarz (29) report a field study of the reactions to sound of moths of the genus Catocala. Some species show instinctive reactions to sounds of high pitch but none gives a reaction to those of lower pitch (256 v.s.). The stimulus was given to the moths resting upon tree-trunks by one experimenter standing behind the tree, the other observing the actions of the moths from a distance. To the Galton whistle the moths react by vibrating the wings or taking flight. To low-pitched sounds they give no response, but when the stimulus has been followed a few times by tactual stimulation the moths learn to respond to the sounds by taking flight.

These results have been confirmed and extended by Turner (28) in a study of silkworm moths confined in the laboratory. The moths were handled roughly after stimulation with sound waves and so were trained to react by vibrating the wings to sounds varying from 64 to 9,290 v.s.

Forbes and Sherrington (7) experimented upon the auditory reactions of a number of cats from which the entire cerebrum and the basic ganglia in front of the anterior colliculi had been removed. From one to four hours after the operations the animals were stimulated with various sounds, whistling, high-pitched Quincke

tubes, barking of a dog, imitation of the same, metallic sounds, shouting, etc. In response to these sounds retraction of the pinna, turning of the head, flexion and extension of the limbs, and lashing of the tail were observed, occurring together or separately. There is some evidence of differential response to the different sorts of stimuli; barking excited more pronounced reactions than metallic sounds or whistling. The movements of the head and pinna are interpreted as orientation reflexes serving to locate the sound. The lashing of the tail was one of the most characteristic and persistent of the responses. It is regarded as a pseudo-affective reflex, "the mimesis although normally concomitant with the emotion of anger was in these experiments exhibited in the absence of the emotion itself."

Shepherd (**26**) tested two cats for discrimination of pitch and intensity of sounds. The cats were to react by climbing or looking up to the top of their cage for food at the positive stimulus and to inhibit movement at the negative. Notes were sounded on harmonica and piano. On the former the animals discriminated one octave, on the latter two. No attempt was made to determine the difference limen more closely than this. The noise of a stick striking a sounding box with controllable force was used as the stimulus for intensity. The cats learned to distinguish sounds of different intensity. The time required for the formation of this habit was less than that of the raccoons and monkeys previously studied by the same method.

Hunter (**15**) records experiments showing sensitivity of the white rat to clangs of different character and its ability to distinguish clangs from pure tones. Further experiments indicated that the rat is insensitive to pure tones between 341.3 and 2,048 v.s. Sensitivity to sounds of very high pitch from the Galton whistle was tested by observing the instinctive reactions of the rats to sounds. To high-pitched pure tones no unequivocal reaction was seen. On the basis of the failure of the rats to react to pure tones Hunter suggests that audition may be found to be divided into sensitivity to clangs and pure tones just as vision may be divided into brightness and color vision. To the reviewer it seems that the response to the high overtones of the clangs has not been eliminated by these experiments. Hunter does not state the ages of the rats tested with the Galton whistle. It has been the reviewer's experience that only very young rats or rats under strychnine react readily to clangs or high-pitched tones of low intensity.

A study of the sensitivity of the dog to rhythm, reported by Usiewitch, is reviewed by Morgulis (21). A dog was trained to react, by the secretion of saliva, to the beats of a metronome oscillating 100 times per minute. After training, each stimulation called forth from six to ten drops of saliva. Change of the rate of beat to 96 or 104 per minute was followed by a cessation of the reaction. The differentiation of these slight intervals persists for 18 hours but vanishes completely after 45. After preliminary training a differentiated stimulus first depresses the salivary flow: this is followed by an increase for the next few trials and then a final complete disappearance.

*Olfactory Sensitivity.*—Risser (24) tested the olfactory sense of toads and tadpoles. Adult toads showed no choice of food on the basis of odor. An air current containing odorous substances was directed to the nostrils. To food odors the animals gave no reaction; to volatile oils and alcohols they reacted by turning away or bending down the head. Toads with the olfactory tracts sectioned did not react to these odors, those with severed ophthalmic branch of the fifth nerve, which supplies the lips and perhaps part of the nasal capsule, reacted normally. Normal tadpoles gathered around packets of food; those with the anterior nares filled with vaseline did not react to the food packets.

Polimanti (23) recorded the number of males and females of the moth *Bombyx mori* which, after emerging, were attracted to and alighted upon other cocoons. Data are given which indicate either that the sense of smell is not well developed in these moths, or that the cocoon membrane effectively prevents the diffusion of smell substances.

Johnson (16) summarizes three possible explanations of the dog's ability to follow a trail without back-tracking. The assumption that the dog follows the trail in the same direction as the quarry because the more recently made tracks have the more intense odor is subject to the objection that the rate of diffusion of smell substances varies with the nature of the ground, and the intensity with the relative speed of the dog and quarry. Other theories assume either an accurate perception of the form of the tracks or the reaction to the combination of the odor of the quarry with the smell substances taken up from the ground and carried along for short distances.

*Vision.*—Ewald (6) finds that for the lateral orientation of *Daphnia* like volumes of light have like effects whether given

intermittently or continuously while for the sense of the reaction, positive or negative, the interrupted light is the more efficient. Specifically different effects are produced by waves from opposite ends of the spectrum. Some evidence of simultaneous and successive contrast is advanced and the attempt is made to differentiate the eye into a central portion sensitive to color and controlling the sense of reaction, and a peripheral portion, color-blind and controlling the orientation.

The appearance of an eyeless individual in his cultures of *Daphnia* lead Herwerden (11) to investigate the sensitivity of *Daphnia* to ultra-violet rays. The results show that the eye is the receptor for these rays.

F. W. G. (9) reviews briefly the work of Frisch and Kupelwieser and raises a point of credit.

Hess (13) finds that the tube-feet of Astropecten are insensitive to red light and sensitive to green. The sensitivity is increased by darkness adaptation. *Holothuria poli* shows a like sensitivity by the contraction of its tentacles. In sea urchins of the genus Centrostephanus the spicules surrounding the anus show reactions to light. They are markedly insensitive to red and respond readily to shorter wave-lengths. Their sensitivity to reduction in intensity is equal to that of man. Hess concludes that all these forms are insensitive to wave-length. Tube worms (Serpula) contract with reduction of light intensity. By shifting from one part of the spectrum to another Hess (12) determined that the point of greatest stimulating value for them lies in the region of the yellow-green to green and that the stimulating value decreases more rapidly toward the red than toward the blue. Similar results were obtained with barnacles.

Frisch (8) advances evidence for a differentiation of the long and short waves of the spectrum in the bee. Color papers were used but in response to the criticisms of Hess and others the possible secondary criteria of odor, relative brightness, absolute brightness, differences in the surfaces of the paper, and chance grouping of the bees were, with the possible exception of the paper texture, thoroughly controlled. The positive color papers were varnished without breaking down the bee's reactions. It would be interesting to know whether a like procedure would lead to a temporary confusion of the cats studied by De Voss and Ganson (5). The bees confused red with black and did not distinguish a certain blue-green from gray. Orange and yellow are not clearly distinguished from

green and the shorter wave-lengths are confused with blue. Bees were trained to distinguish patterns roughly imitating flower patterns and were able to discriminate upon the basis of form as well as of color. When patterns quite unlike natural flower patterns were used the bees failed to make the discrimination.

Hindle (14) painted a piece of cardboard with stripes of different colors, covered the whole with transparent sticky paper, and recorded the number of flies caught upon each color. There was no preference for any color or even for black or white.

Haempel and Kolmer (10) present an interesting paper on chromotropin in dace (*Phoxinus lævis*) and sculpins (*Cottus gobio*).

Laurens (20) studied the reactions of tadpoles of Rana and Amblystoma to light. The frog larvæ, both normal and eyeless, were indifferent to light. Salamander larvæ were sensitive, the great majority being photo-positive. Individuals from which the eyes had been removed were almost as sensitive and positive as normal ones.

Hunter's discussion of form and pattern perception has called forth replies from Johnson and from Bingham. Johnson (17) points out that the method of control suggested by Hunter, the use of alleyways of different forms in the discrimination box, would lead to secondary disturbances in the animals' reactions and, further, doubts the necessity for any control since the background of the stimulus plates is altered by the reversal of their positions.

Bingham (3) recognizes the distinction between pattern and form and distinguishes also the element of "shape." As the reviewer understands this terminology it is based upon three problems: (1) Can the organism give a differential reaction to diverse groups of retinal stimuli (pattern vision); (2) can it give uniform reactions to a constant element common to diverse groups of retinal stimuli (shape perception); (3) can it give uniform reactions to the constant characters of a variable element, as three-sidedness of diverse triangles (form perception).

Tugman (27) gives data upon the threshold of brightness discrimination in the English sparrow, using the Yerkes-Watson brightness apparatus. With one stimulus plate having a luminous intensity of .098 Hefner unit, the other less, the least discriminable difference was, for three birds, .015, .022, and .035 H.U. Under the same conditions the human threshold varied from .009 to .013 H.U.

Coburn (4) finds that the crow is able to distinguish differences

of brightness, size, and form. No attempt was made to determine the difference thresholds.

Johnson (18) outlines a number of problems of visual acuity in animals; the stimulus threshold for striations, the difference threshold for size of striations and direction of visible striæ, and the threshold for brightness contrast. The use of form plates for the study of visual acuity has proved very unsatisfactory owing to the difficulty of controlling the degree of similarity of the plates. Johnson describes apparatus which offers a much more accurate and convenient means of testing acuity. Crossed ruled gratings in especially designed mounts are substituted for the stimulus plates in the Yerkes-Watson discrimination apparatus. These give fields striated alternately black and white, the width and direction of the striæ being varied at will. For tests of brightness discrimination Johnson proposes the use of paired Lummer-Brodhun prisms, each transmitting alternate bands of light from two variable sources.

Using the crossed gratings Johnson studied the visual acuity of the dog, monkey, and fowl, comparing the results with those obtained for man under like conditions. The dog gave no certain result; he was able to recognize the charged punishment grill, probably from the odor of the ozone produced. The thresholds for the other subjects were, in terms of the visual angle subtended by the least visible striæ; monkey, 0′ 57″; chick No. 1, 4′ 04″; chick No. 2, 4′ 14″. The average acuity of four human subjects was 0′ 49″.

Yerkes and Eisenberg (31) trained ring doves to choose the brighter of two lights, then offered them a choice of spectral red and green of approximately equal energy. Twenty trials were given each of two doves light adapted, and the same number after darkness adaptation. Dark adapted, the doves showed a slightly greater preference for the green than when light adapted. This indicates a Purkinje effect of adaptation in these birds. The male dove was somewhat more sensitive to red than the female.

The action currents of the retina under stimulation with light of different wave-lengths give further data upon color vision in birds. Kohlrausch and Brossa (19) studied the action currents of the eyes of small, twilight-flying owls under curare. The eye, dark adapted, was stimulated with light of low intensity from a Nernst projection lamp. Filters transmitting 713–622, 600–540, and 486–414 $\mu\mu$ were interposed and the intensity of the light

regulated until a standard galvanometer deflection was produced. Under these conditions deflections of almost identical form were obtained with all the filters. No differential action of wave-length independent of intensity is demonstrable by the action current. Similar experiments were carried out with light adapted pigeons with higher light intensities. Different galvanometer deflections were obtained with the three filters and the form of the deflection curve remained characteristically distinct for each filter at all light intensities.

The extensive and careful experiments of De Voss and Ganson (5) show how little trust can be placed in positive results on color vision obtained by the use of color papers. The cats were trained to distinguish Bradley colors from Hering gray papers. They were then tested with other grays and found to distinguish the colors from all the grays of the series. Grays of different texture were next tried and finally a gray cambric was found for each color which the cats could not distinguish from the color after 600 trials. They failed to distinguish any color from all shades of gray. A comparison of the brightness values of the grays confused with the colors indicates that red, blue, and violet have low stimulating value for the cat. The color papers were compared and the cats confused those of low stimulating value in one group, and those of higher stimulating value, yellow and green, in another. The work gives almost certain evidence that cats are color blind.

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# RECENT LITERATURE ON HABIT FORMATION, IMITATION, AND HIGHER CAPACITIES IN ANIMALS

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During the first part of the year 1914 we find descriptions of equipment which has been used in several pieces of work published since. Yerkes and Kellogg (26) describe four types of apparatus for obtaining graphic records of the movements of an animal in a maze. Watson (22) describes a circular maze with which one of the graphic methods mentioned above is used.

The development of the fourth floor of Emerson Hall into a laboratory of ten rooms for animal psychology and the establishment of a field station at Franklin, New Hampshire, for both naturalistic and laboratory investigations (26) are important events in the history of the science in this country.

One of the studies carried out at Franklin Station was on the crow (3 and 4). This animal learned to discriminate differences in size of the stimulus regardless of relative intensity, and to react to relative size instead of merely to a specific stimulus. In the second part of the work, the Yerkes multiple-choice method was used. This consists of a series of reaction units, of which, at any given time, one unit will give food or other satisfaction when properly reacted to. This unit is determined by some special relationship of itself to the other units, which basis of determination is to be learned by the animal. Out of the total number of units available, ten different settings or combinations having each three to nine units were used in rotation. In the use of these combinations, the work of each experiment period began where the work of the previous experiment period ceased. Three problems were given to the crow as follows: (1) Selection of the unit first at the right of the series or combination used; (2) selection of the unit second at the left; (3) selection of the unit first at the left. In each case it is necessary to separate the constant relation from the variable accompaniments. One male crow and one female crow were tested. Both solved the first and third problems in from fifty to one hundred trials. Both failed to solve the second problem in five hundred trials. In dealing with the second problem, long periods of correct choices followed by sudden decrease indicate the "trying out" of various reactive tendencies, none of which proved more than partially satisfactory.

Another of the studies carried out by the multiple-choice method was that by Yerkes and Coburn (25) on the pig. The results indicate to the authors an approach to "free ideas" in the pig, although visual and kinæsthetic factors in the main determine its responses. The pig is more independent of the particular situation than is the crow. The multiple-choice method has fully justified itself. It is believed that by means of a series of problems of varying difficulty, the levels of mental development of different individuals, species, etc., can be determined.

In experiments on inbreeding conducted at the Wistar Institute, a strain of albino rats was produced in which the relative brain weights were less than normal. Basset (1) gives data which indicate that this decreased relative brain weight was accompanied by a correspondingly decreased ability to form habits. The Watson circular maze and two inclined plane experiments were used in the tests.

Miss Vincent, in her study of visual control with rats (18), used a maze in which the true path was entirely white, while all cul-de-sacs were black, one in which the true path was black and the cul-de-sacs white, and a normal maze for control. Discrimination was also tested by use of a box having two cylindrical bent tubes placed on opposite sides at floor level as exits. One of these tubes was white inside, the other black; and only the one for which the animal was being trained was left open at the outer end. The animals showed greater accuracy, and, because of accuracy, a shorter time in the early trials in the black and white mazes than in the normal. On the other hand, the contrast of brightness acted as a distraction at times, caused the persistence of a certain degree of error and slow time, and interfered with automatism. Blind rats in the black and white mazes show learning curves similar to those of the normal maze. Normal rats that had worked in the black and white mazes learned the problem box in less trials on account of their experience in the maze.

In the study of olfactory control (19) the maze was well covered with enamel paint, and a paper strip was laid over the bottom of the maze in all alleys. In one experiment an olfactory trail was rubbed along the strip in the true pathway only; in a second experiment it was put in the cul-de-sacs only. In both these tests, the number of errors was decreased compared with a normal maze, more so in the first experiment than in the second. Speed, however, was slow. When the paper was removed from the alleys, the rats ran the maze

as usual, showing that the habit had become kinæsthetic. The rats were then transferred to a problem box in which the kinæsthetic was ruled out, and in which two tubes were presented, one lined with clean paper, the other taken from the maze and carrying the trail. The rats which had been used in the first maze (trail in the true path) followed the scented paper from the maze; those which had been used in the second maze followed the other tube.

In a third paper (20) Miss Vincent used a maze with removable sides, where the alleys were so far apart and elevated that the animal would not jump across when the sides were removed. If the sides were removed after the maze was learned, it had to be in great part relearned. The method of learning when the sides were down showed the importance of the vibrissæ and the tactual sensations from nose and feet.

Szymanski (17) used a box in which the choice at one point should depend primarily upon kinæsthetic factors, at another point upon visual brightness. Rats formed associations on the basis of kinæsthetic factors much more easily than in terms of optical stimuli.

According to Shepherd (16) monkeys promptly pulled food toward the cage by means of a stick to which it was attached, and showed other similar adaptations while dogs and cats failed under analogous conditions. While the difference may be partly due to the superior motor equipment of the primates, the author thinks the monkeys are also much superior in "adaptive intelligence."

Hunter in a reply (9) to Watson's criticisms, shows that in his experiments there was no "error of observation," that there could be no constantly maintained attitudes in the racoons, and that the temperature and odor stimuli were sufficiently controlled to make his deductions valid. He believes that if we are to get at the genesis of the idea function, we shall do it by a study of the delayed reaction.

Schwartz and Safir (15) aimed to determine (1) whether the fiddler crabs can form a simple labyrinth habit, (2) whether the habit is retained for a few days, and (3) whether the habit can be broken up. When the crabs were placed in a box partly full of moist sand, they would at once attempt to escape. They would run to the opposite side of the box and it was noted that nearly all individuals turned toward the right or left corner in their flights. The tendency to escape is so strong that, if brought back time after time, they will make a large number of trials in succession. To

test learning, an individual was released from a triangular enclosure at the center of one side, the distant corner toward which he tended to move was stopped and the other distant corner was made to open into an enclosure containing the animal's burrows. At first the crab slowly and by accident found his way from the closed corner to the open. With repeated trials, the tendency was gradually set up to go more and more directly from the releasing point to the open corner. This new habit persisted after ten days. If the closed corner were then opened and the open corner closed, the habit could be reversed, but the process was slow and gradual. Any establishment of a pathway was prevented by scraping off the top layer of the substratum or by adding a fresh one.

Edinger's work (**5**) is offered as a suggestion of the method by which, before a laboratory investigation is begun, the animal's "mental status" should be taken by careful observation of his daily activities. Material of some value is included, such as the dog's undertsanding of specific words and commands, his lack of insight in applying these to new situations, his tendency to do a thing once taught in a given situation whenever that situation presents itself.

Miss Hubbert (**8**) worked with the circular maze and graphic recording apparatus described by Watson. She recorded the total time required and the total distance run during each trial with twenty-seven rats until the habit was established in each, and then compared the resultant time and distance curves for all the rats combined. The similarity between the two curves was striking. She maintains that it is feasible and desirable to obtain both a time curve and a distance curve, and that it is impossible to "state which is the better criterion of learning. We are sadly in need of a close analysis of just what the time and distance curves mean."

The same writer (**7**) discusses the order of dropping errors in the maze. According to the pleasure-pain theory, errors should be eliminated progressively backwards from the cause of the satisfaction, the food-box. Her work is based on the Watson maze again. A tabulation of her results shows only a very few cases in which there is uniformly progressive elimination of the errors backwards, and only a small per cent. in which the errors in the latter half are dropped before those in the first half.

Pleasure-pain is rather generally regarded as the selective principle in learning. Carr (**2**) offers another suggestion. The animal responds to a situation as a complex series of stimuli. His

action in turn modifies the stimulus and the stimulus changes from trial to trial. Elimination in this process is only a matter of selection of something else; selection is a matter of emphasis. The factors which emphasize the successful act are relative frequency, intensity and recency. In a problem box, the successful act must occur every trial, while a useless act would naturally occur in only half the trials, although at times an error may occur more frequently than the correct act. The successful act is emphasized by its sensory consequences, the fact that the locks, etc., move, that food results. The successful act is the final one, and is therefore not affected by retroactive inhibitiou. In the maze, according to Carr, a blind alley will be traversed only half as often as the adjacent true path; and while the true path encourages freedom, continuity and rapidity of movement, the cul-de-sac means "hesitation, caution, investigation, or disastrous sensory consequences." Hence the greater frequency and intensity of the successful act.

Papers by Haenel (6), Gruber, Ricciarelli, Ferrari, and many others in *Tierseele*, give much the same reports as formerly in regard to the trained horses and dogs of Krall, Frau Moekel, and others. v. Máday (11 and 12) and Schröder (14) protest against the interpretations of Krall and his followers.

Sanford reviews (13) the performances of the trained horses and the findings of Pfungst. Krall, he thinks, has given altogether too little serious attention to tests "without knowledge." Krall maintains that the erratic spelling of the horses indicates independence in thought; but the pure blundering and inaccuracy of the control would give just this result. The horse was unable to respond to simple problems on cards, while he would follow much more complex ones on the blackboard. Sanford remarks that "creatures with such small powers of dissociation (since dissociation is an essential factor in the formation of abstract conceptions)" could never have grasped the abstract relation of the number system. The methods and conditions of work on these animals, and the interpretations growing out of the results are similar to the methods and results of the investigations of the Society for Psychical Research into human experiences.

Volkelt (21) is concerned with the objective or cognitive side of animal consciousness, and would inquire how the objects of the environment appear to an animal. To determine this, he would study cases in which an object has definite value and interest to an animal (such as food, home, etc.), and yet the animal fails to

adapt to it properly. It must be certain that the animal is in condition to have a real "interest" in the object, and that in a different total situation he would respond with adaptive behavior. A summary of Volkelt's work with apt critical comments is given by Hunter (10).

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## SPECIAL REVIEWS

*The Lyriform Organs and Tactile Hairs of Araneads.* N. E. McINDOO. *Proc. Acad. Nat. Sci. Phila.*, 1911. Pp. 43. *The Olfactory Sense of the Honey Bee.* N. E. McINDOO. *Jour. Exp. Zool.*, 1914. Pp. 81. *The Olfactory Sense of Hymenoptera.* N. E. McINDOO. *Proc. Acad. Nat. Sci. Phila.*, 1914. Pp. 47. *The Olfactory Sense of Insects.* N. E. McINDOO. Smithsonian Misc. Coll., No. 2315, 1914. Pp. 63.

The papers listed above present the results of about five years of intensive study upon the olfactory sense of certain hymenopterous insects and spiders. The last paper of the series gives not only a resumé of McIndoo's own researches, but also useful reviews of the observations and conclusions of other workers in this field. Its comprehensiveness is indicated by the number of titles listed, one hundred and sixty-four in all, of which but fifteen were not directly accessible.

McIndoo shows from both morphological and experimental data that the so-called "lyriform" organs are the true olfactory structures of the araneads. Thirty-nine species, representing twenty-seven families, were examined. A lyriform organ is usually composed of several slit-like apertures in the cuticle bounded externally by a lyre-shaped, pigmented border. At the base of each slit lies the peripheral end of a sensory fiber. Lyriform organs are found upon all of the appendages and in certain other locations. Tested spiders make distinct responses to the odors of essential oils, but when the lyriform organs are smeared with vaseline the spiders respond nine times more slowly.

In the leading article of the series McIndoo investigates the sense of smell in the honey bee with particular reference to the

structure and disposition of the sensory organs involved. Crucial tests with odors of essential oils (peppermint, wintergreen, thyme, etc.) and with other substances demonstrate the olfactory capabilities of this insect. Bees under experiment were placed in small cases with glass tops and cheese-cloth bottoms, and the odor was presented by quickly uncorking a small vial containing the odoriferous substance and holding it beneath the individual bee. The reaction time was taken in seconds. As is well known, the antennæ of insects are usually designated as the bearers of olfactory receptors and the current antennæ-odor theory is largely based upon data obtained by mutilation methods. As might be expected, injuries to the antennæ of bees are followed by slower reactions to odors, but McIndoo concludes that retardation of response results primarily from the shock of mutilation rather than from direct injury to olfactory structures. Covering antennæ with glue and burning them off is less injurious than amputation although bees so treated are evidently somewhat abnormal. However, they retain the ability to receive odor stimuli for the average reaction time of worker bees with antennæ burned off is 4 seconds as compared with 2.64 seconds for unmutilated bees. Numerous experiments similar to the above lead McIndoo to reject the idea that the antennæ of the honey bee receive olfactory stimuli.

Sense organs of several types are found upon the antennæ but to none of them does McIndoo assign an olfactory function. In his opinion certain other structures, the "olfactory pores," are the true organs of smell in the bee, and probably in other insects. Similar sense organs were first noted by Hicks (1857–1860) in various insects. McIndoo finds that the olfactory pores of the bee are grouped upon the bases of the wings, upon all of the legs and scattered over parts of the sting. None are found upon the antennæ. In the very extensive experimental work presented in proof of the olfactory function of these pores it is shown that reaction times to odor are greatly lengthened (eight to twelve times) when the pores are covered with a beeswax-vaseline mixture although behavior is normal in all other respects. A correlation is also established between the number of pores characteristic of each cast and the relative sensitivity of the cast.

In the third paper of the series McIndoo shows that olfactory pores of like structure and location to those of the honey bee are found in 29 species representing 22 families of the Hymenoptera. Experimental work upon *Formica obscuriventris*, *Camponotus penn-*

*sylvanicus* and *Vestula maculata* yields results comparable to those obtained with the bee. McIndoo attempts to calculate the relative sensitivity of different species upon the basis of the number of pores present, but an exact evaluation of this relation would seem difficult.

In making a survey of the above papers one is impressed with the painstaking manner in which the work has been conducted, with the variety and ingenuity of the tests employed and, in the case of the honey bee more particularly, with the sound basis of facts from which conclusions are drawn. It would seem well established that the olfactory organs of this insect are the "olfactory pores" and that they are not located upon the antennæ. There can also be little doubt of the presence of similar organs in similar locations on the bodies of the other Hymenoptera studied. Here also experimental results indicate that the antennæ play little or no part in olfactory sensation although the statement that "a few antennæ" (from the 29 species studied) "were hurriedly examined" leaves doubt as to whether or not the organs of Hicks are entirely absent from these structures. It should further be noted that although the olfactory pores may be the "true olfactory apparatus in Hymenoptera" and "the antennæ play no part in receiving odor stimuli" it may yet be doubted if an equally sweeping generalization should be made to include all insects. McIndoo does not hesitate to predict that "when the behavior of insects investigated is thoroughly studied and when experiments are performed in ways other than on the antennæ alone . . . it will be realized that the antennæ can no longer be regarded even as a possible seat of the sense of smell in insects." Such indeed may be the case, but extensive and equally excellent investigations upon other orders will be necessary before this interesting supposition is either established or rejected.

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*Behavior, An Introduction to Comparative Psychology.* J. B. WATSON. New York: Holt & Co. 1914.

This book has been written as a text for students and is to be evaluated in this light. The best organization of any material for the use of students is always a problem, especially in a relatively new subject. As a consequence, the text will probably not meet the entire approval of any teacher, the author himself not excepted.

With a few exceptions the book is simply, concisely and clearly written. It contains three useful chapters not found in such texts: Chapter III gives a good summary of typical kinds of apparatus and methods, material which is difficult to present in class and which the student has been compelled to gather from the various sources. Chapter V gives a good and interesting presentation of the later biological material on the origin of instinct, which should be very useful to all students of psychology without an adequate biological training. Chapter IX deals with the recent work on animal prodigies. The statement, analysis and evaluation of results here given are excellent. The more conventional factual material of comparative psychology is found in the eight chapters on instinct, habit and the senses. Watson is at his best in the summaries, analyses and generalizations of factual material; the treatment is on the whole critical, careful, conservative and free from dogmatism. Some readers may dissent from the overemphasis of the higher animals and the omission of any treatment of the lower organisms, but the author may reply that selection of material is necessary in a book other than a treatise and that he is primarily dealing with types of behavior, and not with animals.

It is in point of view, theory and interpretation that the work will receive the most criticism. As is well known, Watson's point of view is that of "behaviorism" and the first chapter is devoted to an exposition of this doctrine for both human and animal psychology. To the reviewer's mind, "objectivism" is a better term. Watson deals not only with behavior but with the analysis of the sensory situation and the sensory conditions of response, as is well attested by the last four excellent chapters. Furthermore, behavior in the human can be studied by the subjective method, and the term does not differentiate Watson's position from that of some human psychologists who call themselves behaviorists. The essential of Watson's position is not a distinction of subject matter (behavior), but the objective point of view from which it is studied. The larger part of the chapter is devoted to upholding the exclusive use of the objective method in human psychology. This extension of the doctrine to the human realm is out of place in a text on animal psychology. The questions at issue are radically different in the two cases. In the human realm the problem concerns the validity of *introspection* as a means of obtaining data, while in the animal field we are concerned with the validity of an *anthropomorphic interpretation* of factual material. It is easily conceivable for one

to adopt Watson's position in animal psychology and reject it in the human field. The diversion is thus a waste of space and is extremely likely to confuse the issue in the student's mind. One also might wish in a text for students a more impersonal presentation of the various points of view rather than what one may well term a propagandist treatment of the author's attitude. Concerning the rejection of the introspective method, two remarks are appropriate. There is some moral certainty that at least one of the author's pet and fundamental doctrines was attained by this very method, viz., the exclusively motor basis of thought. One may also maintain that introspection is surreptitiously introduced into the system by the use of the "language method." In animals we interpret an act in reference to the animal and the objective situation; with the language report, we cease to regard the response wholly in relation to the objective situation, but we interpret its significance in reference to our own experience subjectively regarded.

In the animal realm, Watson's negative position contends that the objective data shall not be organized and interpreted in reference to determining the conscious states of animals, yet the facts need organization and principles of interpretation, and I do not find Watson's positive program to be very clear in this respect. Like other sciences, the goal of behaviorism is the prediction and control of its phenomena, but with the other sciences this aim is not the final goal for it is prosecuted with the hope of ultimate service to human needs. Prediction and control of animal behavior might be of service to animal trainers and those dealing with domestic animals, or this human service would be rendered if we frankly regard the purpose of animal psychology as a phylogenetic mode of approach to the analysis and comprehension of human intelligent activity. Watson makes statements which can be interpreted in support of both possibilities. On the one hand, all anthropomorphic interpretations and comparisons are anathema, the behavior of amœbæ has a value in and of itself without reference to the behavior of man, and the biologist no more studies animals in reference to the origin and development of the human race. On the other hand, correlation is necessary and one type of correlation demanded is the ontogeny and *phylogeny* of behavior, learning in animals is probably the most important study of behavior on account of its bearing upon human training, and the lack of language differentiates the brute from man. His material is actually organized under the three topics of instinct, habit, and the senses, and I did

not find any satisfactory treatment of the mutual relations of these three divisions in respect to a unitary scheme.

In the chapter on language we have the old question of the existence of ideas, images and thought in animals dressed up in new clothes, so new in fact that the discussion and the bibliography contain no reference to other literature on this topic. In Watson's system, there are no images and what we generally term ideas and thought are merely language habits. Language is considered merely as thought and not in the sense of communication. Not all vocal habits are language, and bodily habits may function as language. The distinction between language habits (thought activities) and other acts is one of function in the objective situation, and the criterion urged is "adaptive substitution." No activities of animals can subserve this function and hence language or thought is absent in animals. It makes no difference whether we call a thought activity, an idea, a memory process, an image, or a language habit, we are dealing with the same old problem of an objective criterion by means of which we can determine the presence or absence of these activities in animal behavior, and other writers to my mind have advanced exactly this same criterion of adaptive substitution. Cole urges the criterion of "varying means to the same end" as one evidence in favor of the existence of ideas in animals, while Hunter reiterates again and again that vicarious substitution is one of the essential functions which a "memory idea" must subserve. The reviewer has no quarrel with the validity of the criteria urged but questions their sufficiency and adequacy, for on this basis I would conclude, contrary to Watson, that all animals possess language or thought.

Objection may be registered to the omission of "sensory consequences" as one of the principles of selection and elimination. The question may best be reserved for experimental decision, though attention may be directed to the fact that Watson favors the use of the consequent of punishment (electric shock) as an eliminative agency.

The treatment of reflex, instinct and habit contains much that is commendable as well as several doctrines which are likely to meet with dissent. All sensory-motor connections (reflex) are hereditary and innate; the only novel acquired factor added by experience is an increase of functional strength due to frequency and recency of activity. We are told that the number of reflexes can not be increased or decreased, no new connections are acquired, all neural channels are preformed, all associations or bonds are given in hered-

ity, and all modification due to learning results from an increase of strength of certain reflexes relative to others. The author comes perilously near to contradicting this conception in his later doctrine of substitution, for we are there informed that a stimulus which originally did not call out a given response comes later to elicit it. Certainly, many coördinations are elicited only because of the exigencies of experimental conditions and the assertion that these are nevertheless due to heredity rather than to experience is somewhat dogmatic. To my mind the author is here using the term "preformed" in the sense of "determined" rather than with the usual meaning of a congenital mode of determination. Habit and instinct refer to a series of reflexes in which the sensory stimulus of any reflex results from the movement of the preceding member of the series. In instinct, the composition of the series is due to the innate strength of the reflexes, while in habit it is due to that element of strength added by experience. The addition of another factor to the definition may be suggested, viz., the idea that these series should possess some degree of reference to a unitary situation to distinguish them from a mere succession of unit acts as when an organism drifts aimlessly about, reacting first to one aspect of the environment and then to another. In Watson's conception each unit of the series appears to be stimulated by the sensory results of the immediately preceding reflex. Any reflex is not conditioned or determined by the resulting physiological states or effects (other than sensory) of the previous acts of the series. There are no neural bonds, links, or causal nexus, between the reflexes for all association obtains *within* a reflex, between the sensory stimulus and the movement. This doctrine is questionable, though the reviewer hesitates to dogmatize concerning it. According to Whitman, the final part of the reproductive cycle of activities in the pigeon is determined by the *exhaustion* resulting from the earlier acts. Transfer of training in the human realm may be mentioned. Watson's conception here seems to imply that the various "neural channels" are isolated and insulated from each other, for the functional potency of any one is determined only by innate conditions and the effects of *its own activity*, viz., recency and frequency. Such an implication does not harmonize with the more prevalent view as to the functional unity of the nervous system.

In conclusion, we may add that an actual trial in the class room has demonstrated the serviceability of this book as a text for students of comparative psychology.

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